A Simulation-based Integration Approach for the First Trident MK6 Life Extension Guidance System

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Report Documentation Page

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a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**			

Outline

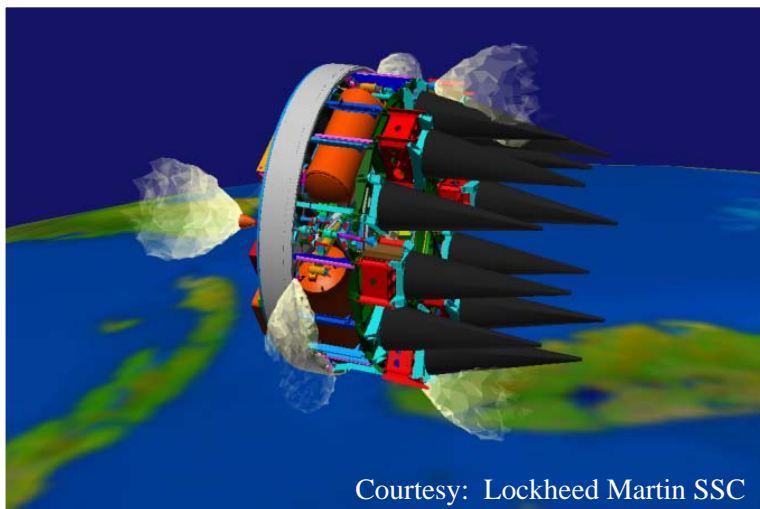- Overview of MK6LE
  - Goal and Timeline of the MK6LE Life Extension
  - Guidance System Objectives and Concept of Operations
  - Guidance System in Context of Weapon System
  - Physical Decomposition of MK6LE
  - Architecture of MK6LE System

- Role of Simulation in Support of MK6LE Development
  - Support Tools and Infrastructure
  - Evolution of Simulations in Support of MK6LE Goals
  - Simulation's Contributions
    - Flight Demonstration at CDR
  - Lessons Learned

- Conclusion

Goal and Timeline of the MK6LE Life Extension

Objective:

Extend service life of the MK6 Guidance System

TRIDENT MK6-LE

2003
Start

2011
1st Flight

2042
Retire

2007
CDR

2013
IOC

Maintain demonstrated accuracy & reliability

Meet all External Coordinated Interfaces / Environments
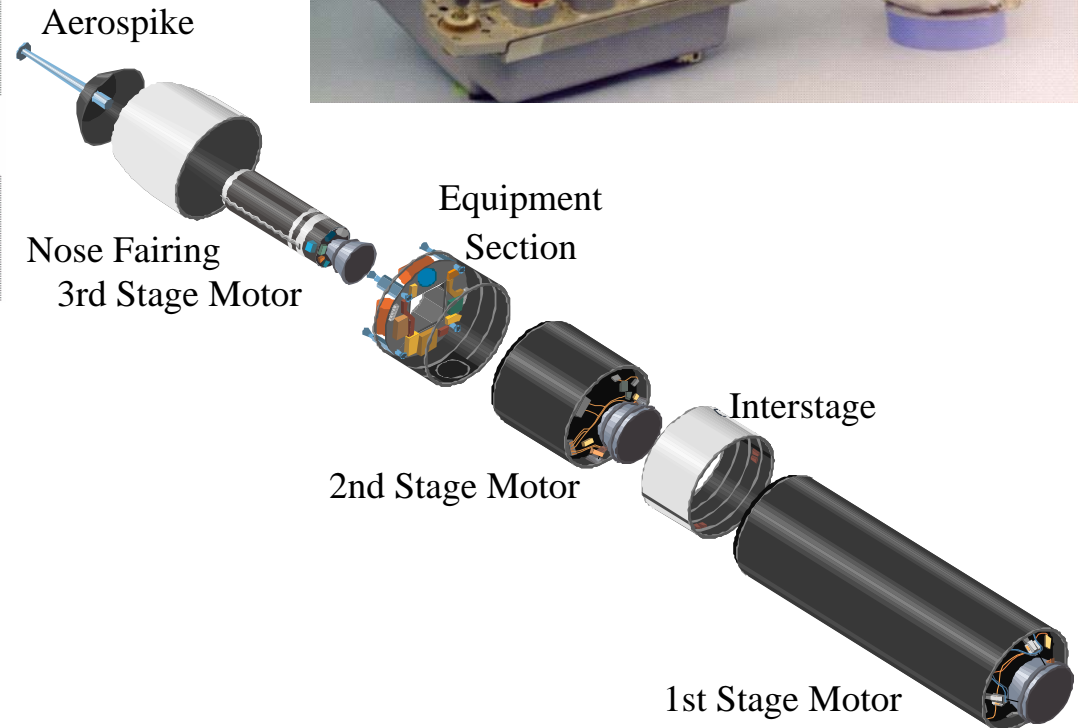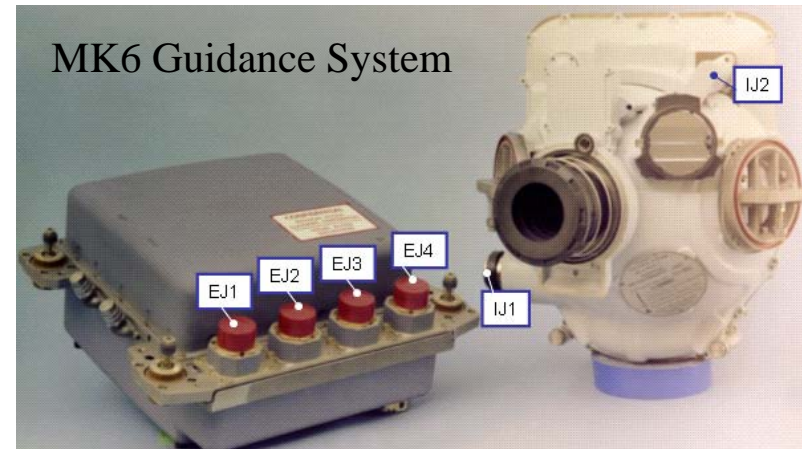
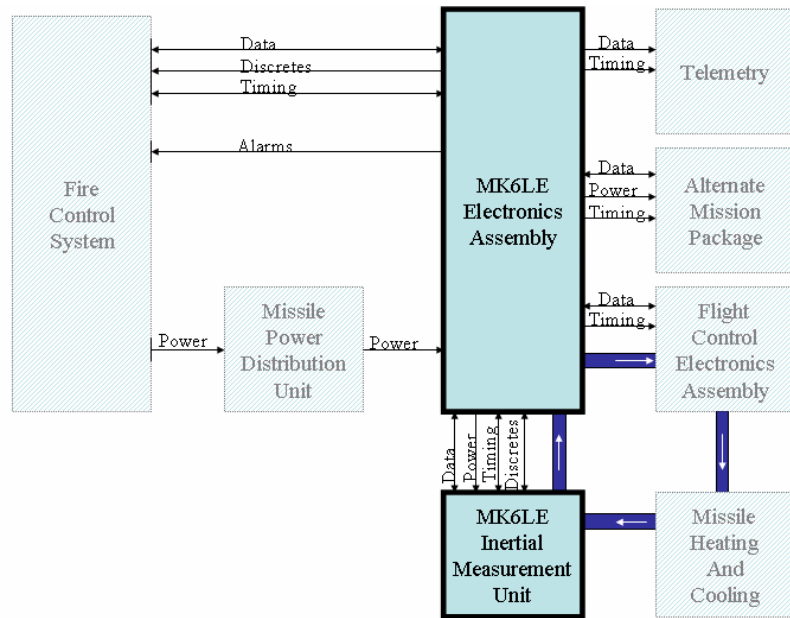**Allow for mission adaptability and technology insertion**

BALLISTIC PHASE

DEPLOYMENT PHASE
(~300 - 600 sec)

BOOST PHASE
(~180 sec)

PRE-LAUNCH AND LAUNCH PHASES

MK6LE Guidance System in Context of Trident Weapon System

MK6 Guidance System

Aerospike

Nose Fairing
3rd Stage Motor

Equipment Section

Interstage

2nd Stage Motor

1st Stage Motor

Courtesy: Lockheed Martin SSC

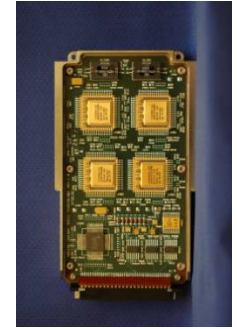# Physical Decomposition of MK6LE

Gyro

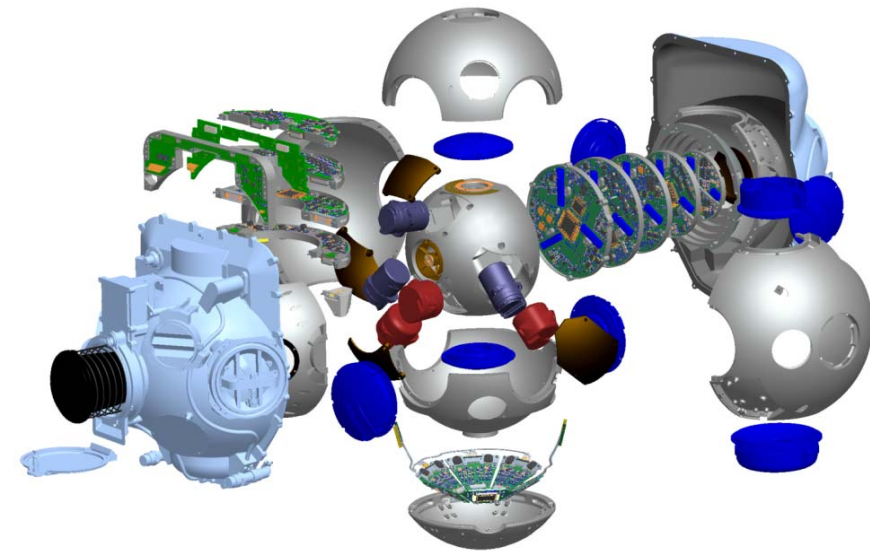IFOG

Accelerometer

Alt PIGA

Camera
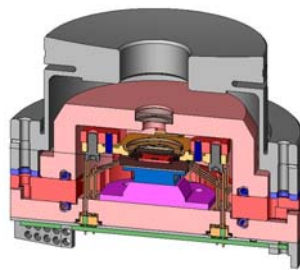
128 x 128 CCD

Computer

RHPPC

MRAM
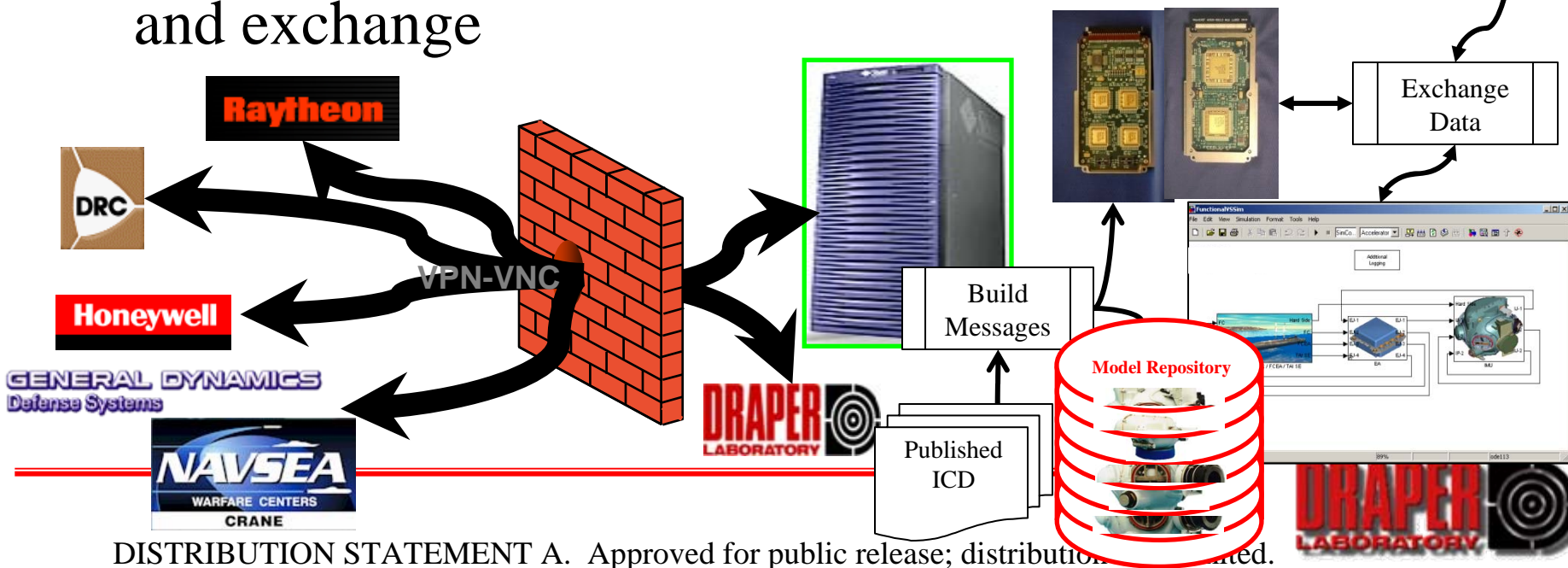Non-volatile
Memory
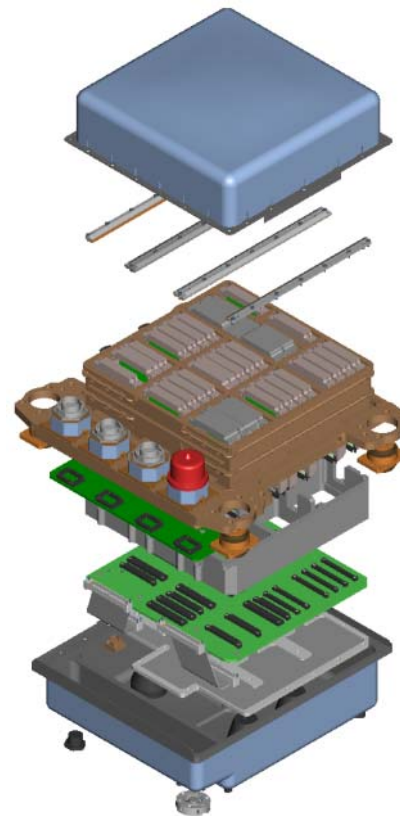
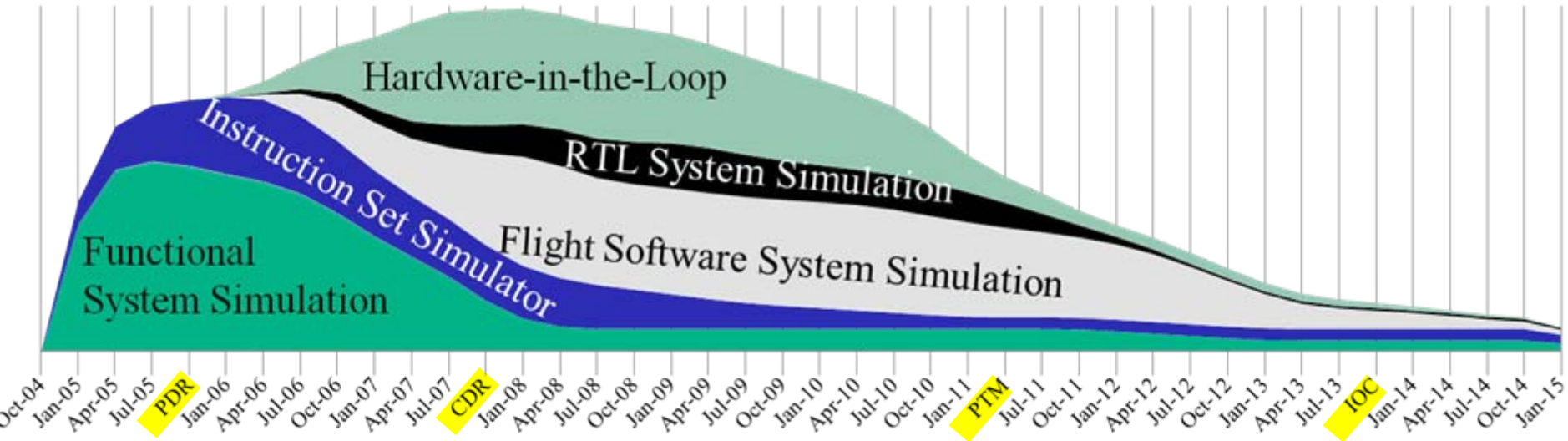# Architecture of the MK6LE System

Support Tools and Infrastructure
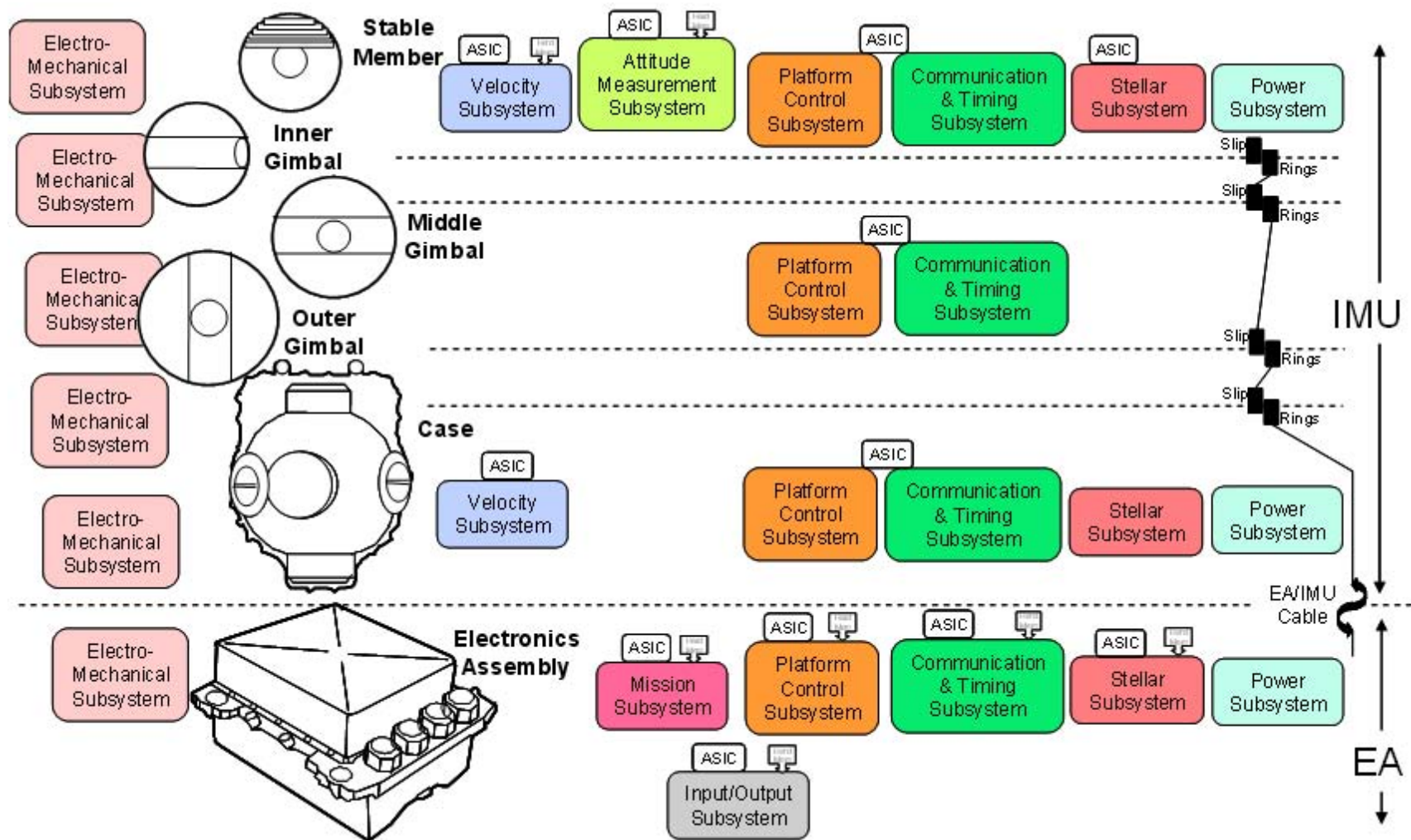
- Central compute facility

- Model Repository

- Auto-coding from ICD

- Test Data Repository

- Scripts for data stripping, scaling, and exchange

Exchange Data

VPN-VNC

Build Messages

Model Repository

Published ICD

Evolution of Simulations in Support of MK6LE Goals

- Managed evolution of simulation capability and appropriate fidelity to meet development need is a key element of the Draper Simulation Based Design methodology

  ➢ "What engineering problem are you trying to solve with simulation?"

- Early identification and planning of simulation needs led to appropriate simulation technology investments.

Simulation's Contributions

- Architecture trade studies and down select.

- Demonstrated execution of MK6LE design by PDR.
  - Early verification of subsystem requirements.
  - Verification and refinement of ICD.

- Supported software development.
  - Developers worked on model of target processor before hardware was available.
  - Defects were identified in a virtual environment before integration with hardware, shortening integration schedule.

- Demonstrated prototype system by CDR.
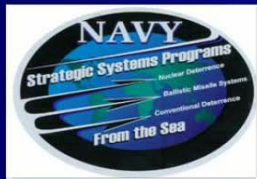 - "Flew" prototype electronics modules built to system specifications in HWiL environment.

Flight Demonstration at CDR

Lessons Learned

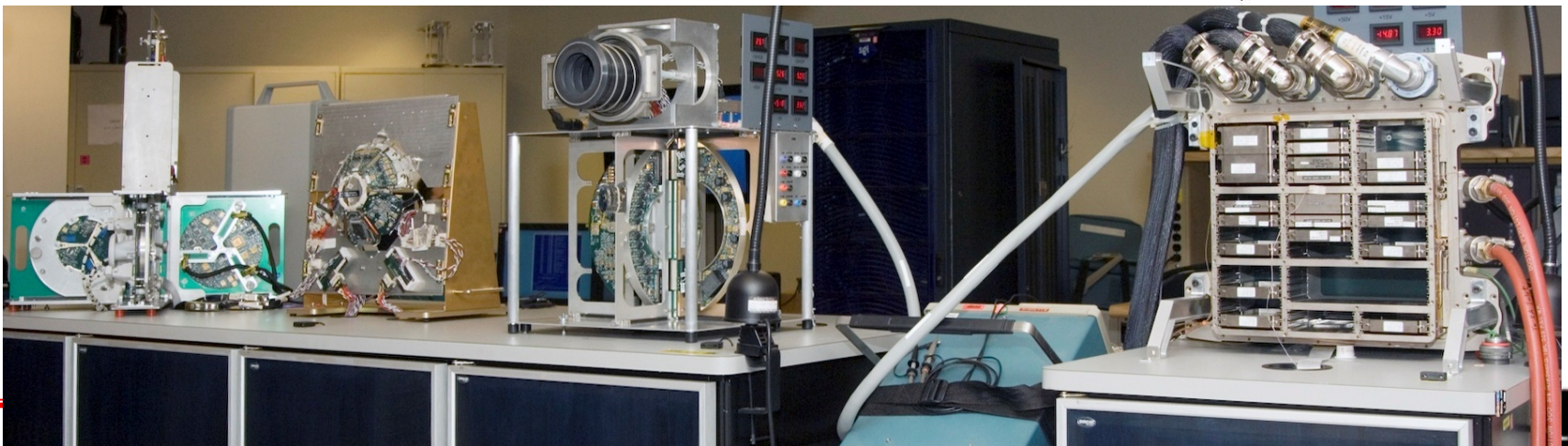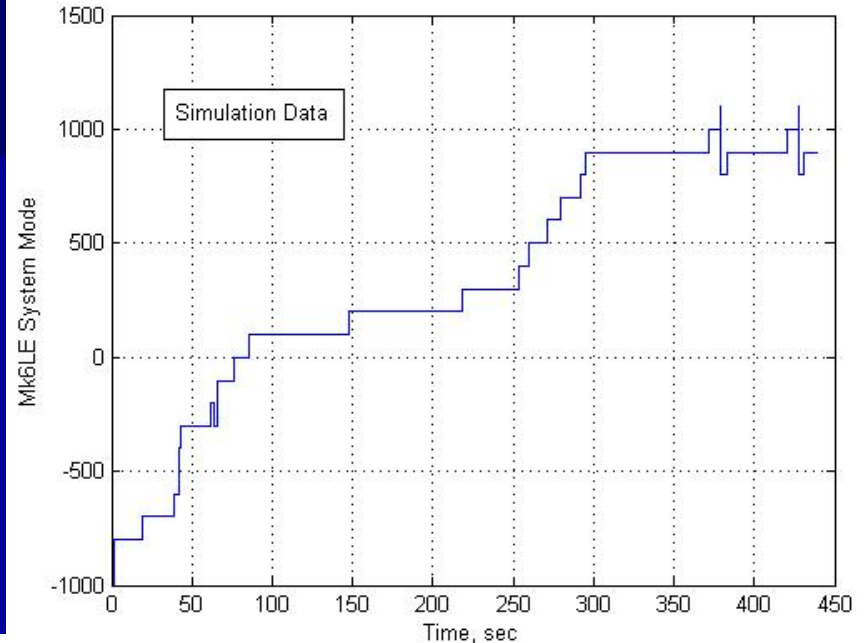- "Design defects" become obvious at the system level.
  - Use simulation and HWiL environments to virtually integrate elements early, don't wait until all hardware is built.

- Capability and knowledge grow exponentially.
  - Re-use models and tools across efforts.
  - Apply COTS solution when applicable.

- Visibility into the system is a challenge.
  - Plan for integration and debug challenges.

- Simulation can be an expensive venture.
  - Cost and development time increase with fidelity…
    …and everybody wants high fidelity.
  - Identify and meet true needs as development progresses.

Conclusion

- Simulation-based design was invaluable for MK6LE
  - Rich set of simulation environments tailored to meet unique guidance system development needs
- Early integration of the Mk6LE prototype design was extremely beneficial
  - CDR Demonstration goal of HWIL Mk6LE Missile Flight focused the entire design team and matured the design.

- Managed evolution of simulation fidelity to meet development need was a key element of MK6LE's success.